Semester Two Examination, 2017

Question/Answer Booklet

CHEMISTRY

Student Name

ANSWERS

_____

Student Number: In figures								

In words _____ _____

_____ _____

Time allowed for this paper

Reading time before commencing work: ten minutes
Working time for paper: three hours

Material required/recommended for this paper

To be provided by the supervisor
This Question/Answer booklet
Multiple-choice answer sheet
Chemistry Data booklet

To be provided by the candidate
Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, correction fluid/tape, eraser, ruler, highlighters

Special items: non-programmable calculators approved for use in this examination

Important note to candidates

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised material. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of examination
Section One Multiple-choice	25	25	50	25	25
Section Two Short answer	8	8	60	70	35
Section Three Extended answer	5	5	70	80	40
				Total	100

Instructions to candidates

1. The rules for the conduct of Western Australian Certificate of Education course examinations are detailed in the *Year 12 Information Handbook 2017*. Sitting this examination implies that you agree to abide by these rules.

2. Answer the questions according to the following instructions.

   Section One: Answer all questions on the separate Multiple-choice answer sheet provided. For each question, shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square, then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

   Sections Two and Three: Write your answers in this Question/Answer booklet.

3. When calculating numerical answers, show your working or reasoning clearly. Your working should be in sufficient detail to allow your answers to be checked readily and for marks to be awarded for reasoning. Express numerical answers to the **appropriate number of significant figures** and include appropriate units where applicable.

4. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.

5. Additional working space pages at the end of this Question/Answer booklet are for planning or continuing an answer. If you use these pages for planning, indicate at the original answer, the page number it is planned/continued on and write the question number being planned/continued on the additional working space page.

6. The Chemistry Data booklet is not handed in with your Question/Answer booklet.

Section One: Multiple-choice Answers

Question	Correct response
1	D
2	D
3	D
4	B
5	C
6	C
7	B
8	D
9	B
10	C
11	C
12	B
13	D
14	Any
15	A
16	D
17	C
18	A
19	D
20	C
21	C
22	D
23	C
24	A
25	B

Section One: Multiple-choice **25% (25 marks)**

This section has **25** questions. Answer **all** questions on the separate Multiple-choice answer sheet provided. For each question, shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square, then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Suggested working time: 50 minutes.

Questions 1 and 2 relate to the following reaction:

$$4\ NH_3(g) + 3\ O_2(g) \rightleftharpoons 2\ N_2(g) + 6\ H_2O(g) \quad \Delta H = -1267\ kJ$$

1. Which one of the following will increase the yield of this reaction?

   (a) increasing the temperature
   (b) dissolving the ammonia gas in water
   (c) adding a catalyst
   (d) increasing the volume of the reaction vessel

2. Which one of the following will increase the rate of the reverse reaction?

   (a) decreasing the temperature
   (b) increasing the volume of the reaction vessel
   (c) removing N_2 from the reaction vessel
   (d) adding a catalyst

3. Carbon monoxide and chlorine react according to the equation shown below.

   $$CO(g) + C\ell_2(g) \rightleftharpoons COC\ell_2(g)$$

   The forward reaction is exothermic.

   A mixture of CO, $C\ell_2$, and $COC\ell_2$ are at equilibrium at 1000 ^{O}C. If this mixture is cooled to 500 ^{O}C while keeping the volume the same, a new equilibrium will be established. Which of the following statement correctly describes the system at the new equilibrium?

   (a) the concentration of CO will increase
   (b) the concentration of $COC\ell_2$ will decrease
   (c) the value of K will decrease

(d) the value of K will increase

4. Which one of the following statements describing the Brønsted-Lowry theory of acids and bases is true?

(a) The conjugate base of a weak acid is always a strong base.

(b) The anion produced by the ionisation of ethanoic acid in water is basic.

(c) All bases dissociate to form hydroxide ions in solution.

(d) The hydronium ion (H_3O^+) is the conjugate acid of the hydroxide ion.

5. Which one of the following species **cannot** act as a Brønsted-Lowry acid?

(a) HCO_3^-

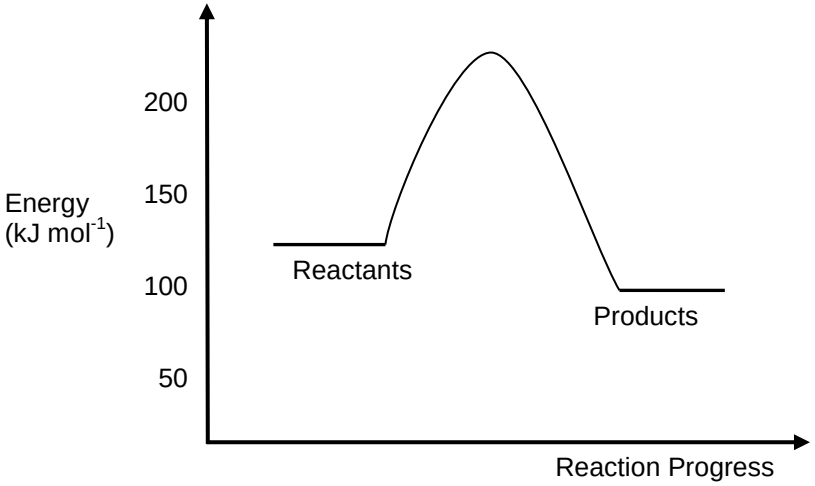
(b) H_2O

(c) $C_2O_4^{2-}$

(d) HSO_4^-

The following information relates to question 6

An energy profile diagram for a reversible chemical reaction is shown below.



6. Which one of the following is true?

(a) The forward reaction is endothermic.

(b) Adding a suitable catalyst can reduce the enthalpy change for the reaction.

(c) The activation energy for the reverse reaction is higher than for the forward reaction.

(d) Increasing the temperature will reduce the rate of the forward reaction.

7. Each of the following substances was dissolved in water. Which one of the following answers correctly classifies the resulting solutions?

	$NaHCO_3(aq)$	$KC\ell(aq)$	$NaHSO_4(aq)$	$NH_4NO_3(aq)$
(a)	acidic	basic	acidic	neutral
(b)	basic	neutral	acidic	acidic
(c)	basic	neutral	basic	neutral
(d)	neutral	neutral	acidic	acidic

8. A solution of sodium hydroxide with a pH of 10 was diluted so that the concentration of hydroxide ions was reduced by a factor of 100. Which one of the following would be the pH of the resulting solution?

(a) 0.1

(b) 9

(c) 12

(d) 8

9. Which one of the following combinations will form a buffer solution?

(a) $HNO_3(aq)$ / $NO_3^-(aq)$

(b) $HSO_4^-(aq)$ / $SO_4^{2-}(aq)$

(c) $NH_4C\ell$ (aq) / $NH_4NO_3(aq)$

(d) $H_2SO_4(aq)$ / $HSO_4^-(aq)$

10. In which one of the following reactions is water acting as a reducing agent?

(a) $2\ Na(s) + 2\ H_2O(\ell) \rightarrow 2\ Na^+(aq) + 2\ OH^-(aq) + H_2(g)$

(b) $CO_2(s) + H_2O(\ell) \rightleftharpoons H_2CO_3(aq)$

(c) $4\ C\ell O^-(aq) + 2\ H_2O(\ell) \rightarrow C\ell_2(g) + 4\ OH^-(aq) + O_2(g)$

(d) $H_2CO_3(aq) + H_2O(\ell) \rightleftharpoons HCO_3^-(aq) + H_3O^+(aq)$

The following information relates to question 11

During an experiment to establish the concentration of an oxalic acid solution, a student carried out the following steps.

- Rinsed a burette with distilled water.
- Rinsed a conical flask with distilled water.
- Filled the burette with a standardised sodium hydroxide solution.
- Rinsed a pipette with the solution of oxalic acid.
- Dispensed 25 mL of oxalic acid into the conical flask using the pipette.

11. What effect would her procedure have had on the accuracy of her results?

(a) A larger volume of sodium hydroxide is needed to reach the end point, and the calculated concentration of oxalic acid would have been too low.

(b) A smaller volume of sodium hydroxide is needed to reach the end point, and the calculated concentration of oxalic acid would have been too low.

(c) A larger volume of sodium hydroxide is needed to reach the end point, and the calculated concentration of oxalic acid would have been too high.

(d) A smaller volume of sodium hydroxide is needed to reach the end point, and the calculated concentration of oxalic acid would have been too high.

The following information relates to question 12

The metals Hg, Cd, Ga and Pd react as follows:

$$3\ Pd^{2+} + 2\ Ga \rightarrow 2\ Ga^{3+} + 3\ Pd$$

$$Cd + Ga^{3+} \quad \text{no reaction}$$

$$Hg^{2+} + Pd \rightarrow Pd^{2+} + Hg$$

12. Which of the following metals is the strongest reducing agent?

(a) Pd

(b) Ga

(c) Cd

(d) Hg

13. Consider the following reaction:

$C\ell O_3^- + H_2O_2 \rightarrow C\ell O_4^- + H_2O$

For this reaction, which one of the following is true?

(a) Chlorine is undergoing disproportionation (oxidised and reduced).

(b) Hydrogen peroxide is being oxidised.

(c) The $C\ell O_3^-$ is acting as an oxidising agent.

(d) The oxidation state of hydrogen remains unchanged.

14. Which one of the following substances is capable of oxidising lead metal but not zinc metal?

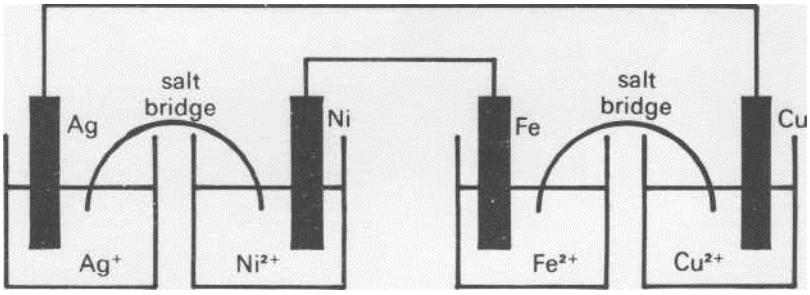
(a) Co

(b) $AgNO_3$

(c) $CdBr_2$

(d) $MgC\ell_2$

The following diagram relates to question 15 and shows two cells set up in series



Cell1 Cell 2

15. Which of the following statements **best** describes the processes occurring in the two cells?

(a) Cell 1 behaves as an electrochemical cell, and electrolysis occurs in cell 2.

(b) Cell 2 behaves as an electrochemical cell, and electrolysis occurs in cell1.

(c) Both cells 1 and 2 behave as electrochemical cells.

(d) Electrolysis occurs in both cells 1 and 2.

16. Silver oxide button cells are primary cells used in devices such as watches and hearing aids. The two half half-equations involved in these cells are shown below.

$$Zn(s) + 2\ OH^-(aq) \rightarrow ZnO(s) + H_2O(\ell) + 2\ e^-$$

$$Ag_2O(s) + H_2O(\ell) + 2\ e^- \rightarrow 2\ Ag(s) + 2\ OH^-(aq)$$

Which one of the following statements regarding the silver oxide cell is true?

(a) Zinc is acting as the cathode in the cell.

(b) Electrons flow from the anode to the cathode through the electrolyte.

(c) Water will be used up as the cell discharges.

(d) Silver oxide is being reduced as the cell discharges.

17. Steel motorcycle fittings are often electroplated with nickel and then plated with chromium to improve their appearance and resistance to corrosion (the nickel is used to help the chromium adhere to the object). An experiment is set up to electroplate a motorcycle headlight with nickel.

Which one of the following statements describes how the experiment should be set up?

(a) The cathode is made of nickel and the headlight is the anode.

(b) The headlight is the anode and the electrolyte is a solution of nickel sulfate.

(c) The headlight is the cathode and the electrolyte is a solution of nickel nitrate.

(d) The headlight is the cathode; the anode is made of steel and the electrolyte is nickel carbonate.

18. Which one of the following statements about soaps is correct?

(a) Soaps are typically the sodium or potassium salts of fatty acids.

(b) Soaps act as surfactants because they contain ions with a positively charged end and a negatively charged end.

(c) Soaps are manufactured by using an esterification reaction.

(d) Glycerol is used as a reactant in the manufacture of soaps.

19. Which one of the following has a different empirical formula to the other three?

(a) butanoic acid

(b) methyl propanoate

(c) ethanal

(d) propyl propanoate

20. Ethanol is removed from the body by reacting with the enzyme *alcohol dehyrogenase* (ADH). ADH can react with any alcohol that has a hydrogen atom bonded to the carbon to which the hydroxyl group is attached. The effect of the enzyme is to remove this hydrogen and the hydrogen from the hydroxyl group. ADH like all enzymes is very specific and will not catalyse any other reactions.

Which of the following statements about reactions of ADH with alcohols is **not** correct?

(a) The product formed by the reaction of a primary alcohol with ADH is an aldehyde.
(b) The product formed by the reaction of a secondary alcohol with ADH is a ketone.
(c) The product formed by the reaction of a tertiary alcohol with ADH can either be an aldehyde or a ketone.
(d) A tertiary alcohol does not react with ADH.

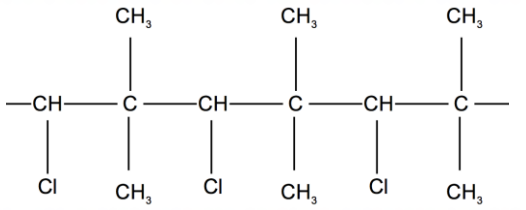
21. Which one of the following pairs of compounds would produce biodiesel if reacted together?

(a) a triglyceride and a strong alkali
(b) a carboxylic acid and a strong oxidising agent
(c) an alcohol and a triglyceride
(d) a fatty acid and an ester

22. Which one of the following dipeptides would be produced by the reaction of valine and serine?
(Use the structures of amino acids given in your Data Booklet to help with this question)

(a) $HOOCCH(CH_3)NHCOCH(CH_3)_2NH_2$
(b) $CH_3CH(CH_2OH)NHCOCH(CH(CH_3)_2)NH_2$
(c) $HOOCCH(CH_3)NHCOCH(CH(CH_3)_2)NH_2$
(d) $HOOCCH(CH_2OH)NHCOCH(CH(CH_3)_2)NH_2$

23. Which one of the monomers shown below can be used to synthesise the following polymer?



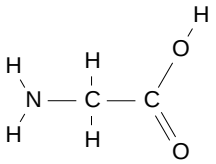
(a) 1-chloro-2,2-dimethylethene

(b) 1-chlorobut-2-ene

(c) 1-chloromethylpropene

(d) 3-chloro-2-methylbut-2-ene

24. Consider the amino acid with the structural formula below:



Which one of the following is true?

(a) A solution of the amino acid can act as a buffer.

(b) The amino acid has a lower melting point than propanoic acid.

(c) The amino acid can form an addition polymer with itself.

(d) In an acidic solution, the amino acid exists as an ion with an overall negative charge.

25. Which one of the following statements regarding ß-pleated sheets in proteins is true?

(a) The ß-pleated sheets form part of the tertiary structure of proteins.

(b) Hydrogen bonds are responsible for the formation of the ß-pleated sheets.

(c) The ß-pleated sheet structure is created when side chains on the protein interact.

(d) A protein that contains ß-pleated sheets cannot also contain the α-helix structure.

End of Section One

Section Two: Short answer **35% (70 Marks)**

This section has **8** questions. Answer **all** questions. Write your answers in the spaces provided.

Additional working space pages at the end of this Question/Answer booklet are for planning or continuing an answer. If you use these pages for planning, indicate at the original answer, the page number it is planned/continued on and write the question number being planned/continued on the additional working space page.

Suggested working time: 60 minutes.

Question 26 **(9 marks)**

The **Haber process (**also called the **Haber–Bosch process)** is an artificial nitrogen fixation process and is the main industrial procedure for the production of ammonia today. It is named after its inventors, the German chemists Fritz Haber and Carl Bosch, who developed it in the first half of the 20th century. The process converts atmospheric nitrogen (N_2) to ammonia (NH_3) by a reaction with hydrogen (H_2) using a metal catalyst under high temperatures and pressures:

$$N_2 + 3\ H_2 \rightleftharpoons 2\ NH_3 \quad (\Delta H° = -91.8\ kJ) \Rightarrow (\Delta H° = -45.8\ kJ \cdot mol^{-1})$$

Nitrogen (N_2) is very unreactive because the molecules are held together by strong triple bonds. The Haber process relies on catalysts that accelerate the breaking of this triple bond.

The Haber process produces 450 million tonnes of nitrogen fertilizer per year, mostly in the form of anhydrous ammonia, ammonium nitrate, and urea. Three to five percent of the world's natural gas production is consumed in the Haber process (around 1–2% of the world's annual energy supply). In combination with pesticides, these fertilizers have quadrupled the productivity of agricultural land.

If the average crop yields remained at the levels obtained in the year 1900, the land needed to feed the world population in the year 2000 would have required nearly four times more land and the cultivated area would have claimed nearly half of all ice-free continents.

Due to its dramatic impact on civilization’s ability to grow food, the Haber process served as the "detonator of the population explosion". Enabling the global population to increase from 1.6 billion in 1900 to in excess of 7 billion in the first decade of the 21st century.

(a) With reference to Le Chateliers Principle and collision theory to explain why the following conditions are employed in the production of ammonia using the Haber process:

(i) Temperature of 400^{o}C is maintained during the continuous process

(2 marks)

Description	Marks
Faster reaction rate	1
Shift equilibrium to favour reverse endothermic reaction	1
Wrong chemistry penalised.	
Total	**2**

(ii) Pressure of is maintained between 15 MPa and 20 MPa

(2 marks)

Description	Marks
Faster reaction rate	1
Shift equilibrium to favour forward reaction	1
Wrong chemistry penalised.	
Total	**2**

(iii) Ammonia is constantly removed from the system.

(2 marks)

Description	Marks
Reduces concentration of products	1
Shift equilibrium to favour forward reaction	1
Wrong chemistry penalised. In particular "forward rate increases"	
Total	**2**

(b) Using reference to intermolecular forces explain how the design of the manufacturing plant can remove the ammonia and return any unreacted gases in to the reacting vessels

(3 marks)

Description	Marks
Ammonia has hydrogen bonding hence highest boiling point	1
Cool to condense ammonia first to remove as liquid	1
Hydrogen and Nitrogen remain gaseous and returned to heated reaction vessel/area	1
Dissolve in water – 1 MAX	
Total	**3**

Students should pay attention to marks allocation on questions. This question uses terms to allude to rate and yield. It asks you to explain why a condition is used. You use high pressure to increase reaction rate. Going into a detailed first principles explanation of why pressure increases rate is a different question or would be allocated more than 1 mark.

Question 27 **(6 marks)**

A student investigated changes to the following equilibrium.

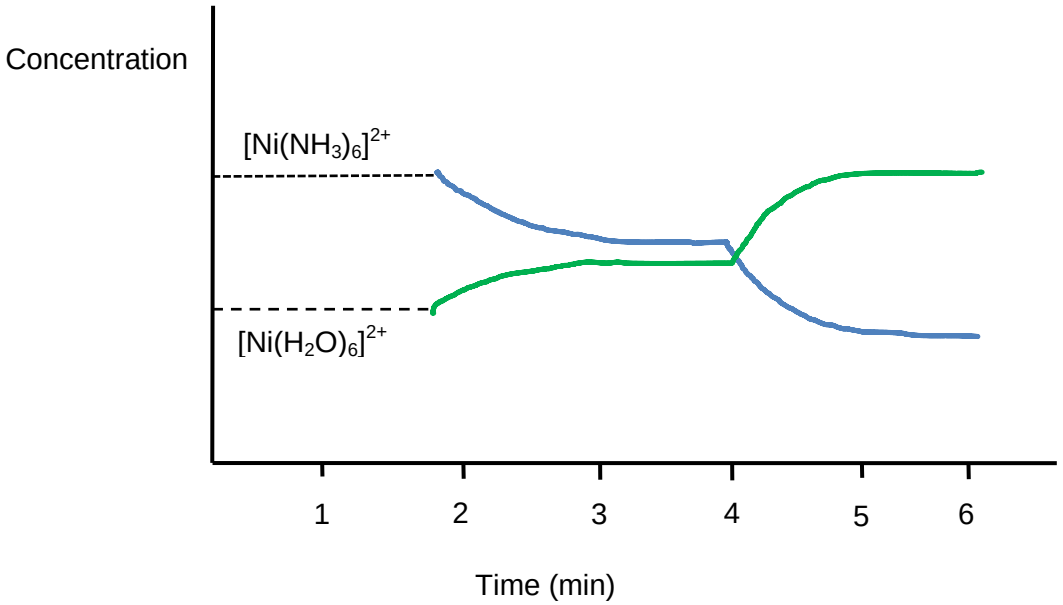
$[Ni(H_2O)_6]^{2+}_{(aq)}$ + 6 NH_3(aq) ⇌ $[Ni(NH_3)_6]^{2+}_{(aq)}$ + 6 $H_2O(\ell)$ ΔH (+) ve

green blue

50 mL of the nickel hexamine ion solution had 3 drops of concentrated hydrochloric acid added at t = 2 minutes. The solution turned green and was left to return to a state of equilibrium at t = 3 minutes.
At t = 4 minutes the solution was paced in an ice bath reducing the temperature from 20 ^{O}C to a constant temperature of 0 ^{O}C.

(a) Complete the following graph showing the changes to the concentrations of the $Ni(NH_3)_6]^{2+}$ and ions until t = 5 minutes.

(4 marks)



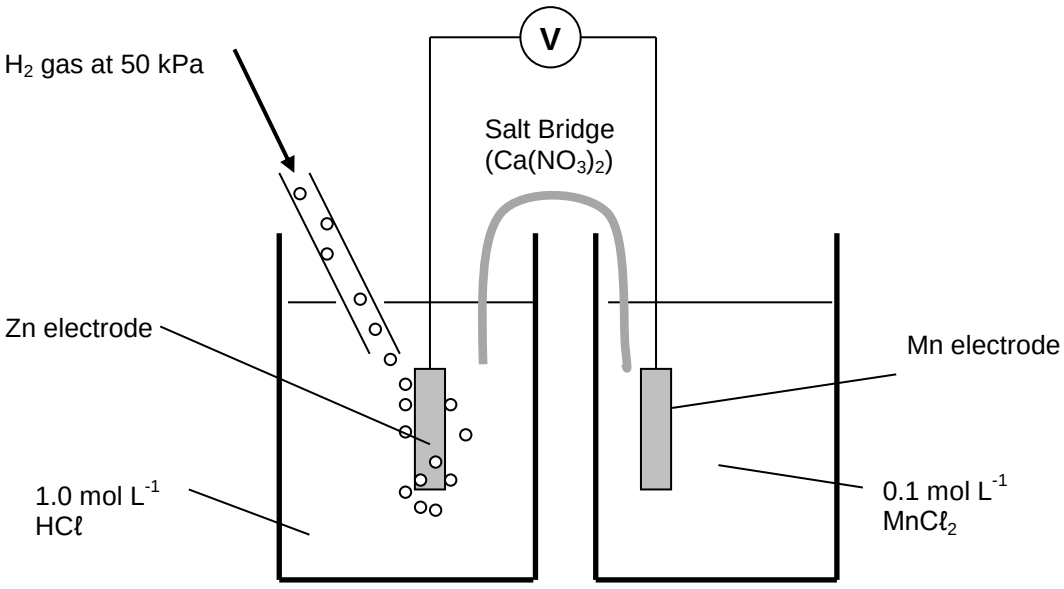
Description	Marks
Correct shapes of both graphs from t=2 to t=3 - hexamine falling with curve - hydrated ion rising with curve	1
t=3 to t=4 both are horizontal lines	1
Correct shapes of both graphs from t=4 to t=5 - hexamine falling with curve - hydrated ion rising with curve	1
Mole for mole increase/decrease	1
Concentration does not spike – common mistake **Total**	**4**

(b) Describe the colour changes expected over the same time. (2 marks)

Description	Marks
Blues solution turns green by t=3	1
Remains green/green intensifies	1
Total	**2**

Question 28 **(7 marks)**

The following electrochemical cell, was used to measure the standard reduction potential of manganese. The reaction was carried out 30°C.



(a) State four (4) reasons why the measured cell reduction potential of manganese was different than expected. (4 marks)

Description	Marks
Any four of: • hydrogen gas should be at a pressure of 100/101.3 kPa *(don't accept just 'wrong pressure')* • temperature should be 25°C *(don't accept just 'wrong temperature')* • zinc electrode should not be used as an inert electrode should be used / zinc will react with the HCl acid • manganese chloride should have concentration of 1.0 mol L^{-1}	0–4
Total	**4**

(b) (i) On the diagram, show the flow of electrons and of ions. (1 mark)

Description	Marks
Electrons from Mn to Zn electrodes Should be in wires Negative ions from Zn to Mn electrodes Should be in salt bridge Positive ions from Mn to Zn electrode Very few students included ions particularly positive ions	1
Must show all three	
Total	**1**

(ii) Explain the consequence of the decision to replace calcium nitrate in the salt bridge with silver nitrate. (2 marks)

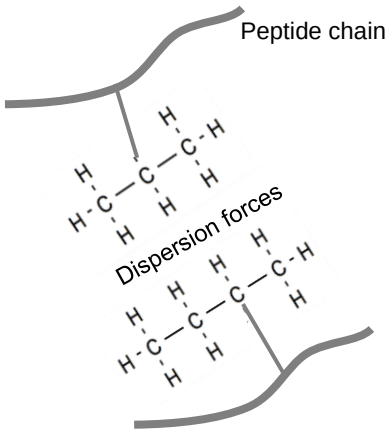
Description	Marks
Silver ions form silver chloride precipitate	1

Consumption of silver ions prevent movement of ions/completion of cell	1
Total	**2**

Question 29 **(11 marks)**

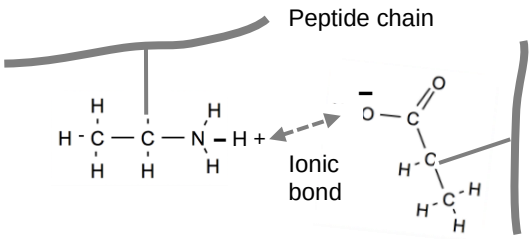
The tertiary structure of proteins is caused by a variety of types of bonding between side groups on the amino acids that make up the protein.

(a) Draw a labelled diagram to show how <u>dispersion forces alone</u> can occur between two side chains on a protein molecule. (2 marks)



Description	Marks
Non-polar chains shown aligned	1
Correct label for dispersion forces	1
Best answer would include valid side chains in full	
Total	**2**

(b) Draw a labelled diagram to show how <u>ionic bonding</u> can occur between two side chains on a protein molecule. (3 marks)



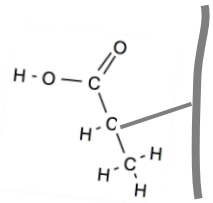
Description	Marks
suitable side chains As above	1
charges correctly shown <u>on side chains</u>	1

correct label for ionic bond	1
Total	**3**

(c) In the case of ionic bonding in part (b), the strength of the attractions between the side groups will be dependent on the pH of the environment that the protein is in.

(i) Using your answer to part (b) above, explain why the strength of the ionic bond will be reduced if the protein was placed in a highly acidic solution.

(3 marks)



Description	Marks
the carboxylate (anionic) group will lose its charge	1
Due to protonation – explanation/diagram	1
therefore no longer an ion / only dipole-dipole (or ion-dipole) forces would be present	1
Total	**3**

(ii) Explain briefly why an alteration in the strength of this bonding may affect the function of the protein molecule. (3 marks)

Description	Marks
The function of the protein molecule is (often) dependent on its tertiary structure	1
The tertiary structure of the protein is held in place by these intermolecular bonds	1
If the strength of this bonding reduces, the tertiary structure might change thus affecting the function of the protein	1
Total	**3**

Question 30 **(11 marks)**

Describe how you could distinguish between the following pairs of compounds using chemical tests. For each test, write one equation for a reaction that occurred. The use of an indicator is **not** considered to be a chemical test.

<table>
<tr><th></th><th>Compounds</th><th>Description of Test</th><th>Observations</th></tr>
<tr><td rowspan="3">(a)</td><td>pentan-1-ol</td><td rowspan="2">either: Add a solution of acidified potassium permanganate to both substances (and warm)
or: Add a solution of acidified sodium/potassium dichromate to both substances (and warm)</td><td>pentan-1-ol
either: purple colour fades
or: orange solution turns (deep) green</td></tr>
<tr><td>2-methylbutan-2-ol</td><td>2-methylbutan-2-ol

No visible change</td></tr>
<tr><td colspan="3">Equation: (state symbols not required)

either: 5 $CH_3CH_2CH_2CH_2OH$ + 4 MnO_4^- + 12 H^+ $\rightarrow$ 5 $CH_3CH_2CH_2COOH$ + 4 Mn^{2+} + 11 H_2O
or: 3 $CH_3CH_2CH_2CH_2OH$ + 2$Cr_2O_7^{2-}$ + 16H^+ $\rightarrow$ 3 $CH_3CH_2CH_2COOH$ + 4Cr^{3+} + 11H_2O

or accept equations to produce the aldehyde:
either: 5 $CH_3CH_2CH_2CH_2OH$ + 2 MnO_4^- + 6H^+ $\rightarrow$ 5 $CH_3CH_2CH_2CHO$ + 2Mn^{2+} + 8H_2O
or: 3 $CH_3CH_2CH_2CH_2OH$ + $Cr_2O_7^{2-}$ + 8 H^+ $\rightarrow$ 3 $CH_3CH_2CH_2CHO$ + 2 Cr^{3+} + 7 H_2O</td></tr>
<tr><td rowspan="2">(b)</td><td>a solution of methylpropan-2-ol</td><td rowspan="2">Add a carbonate (solid or solution) to each of the solutions.</td><td>methylpropan-2-ol

No visible change</td></tr>
<tr><td>a solution of propanoic acid</td><td>propanoic acid

Colourless gas produced</td></tr>
</table>

	Equation: (state symbols **required**) *either (for solid):* $CH_3CH_2COOH(aq) + Na_2CO_3(s) \rightarrow 2Na^+(aq) + 2CH_3CH_2COO^-(aq) + H_2O(\ell) + CO_2(aq)$ *or (for solution):* $CH_3CH_2COOH(aq) + CO_3^{2-}(aq) \rightarrow CH_3CH_2COO^-(aq) + H_2O(\ell) + CO_2(g)$

Description	Marks
(a)	
correct test chosen	1
correct positive test observation	1
correct negative test observation	1
correct half equations Not required for full marks if final equation correct but good luck with that.	2
equation balanced So 0/3 if no half equations and equation incorrect	1
(b)	
correct test chosen	1
correct positive test observation	1
correct negative test observation	1
correct equation	1
correct state symbols	1
Total	**11**

N.B
Relative rate of Na reaction in a) – 2 max. Way more conclusive tests available

Use of oxidation in b) incorrect as tertiary alcohol – 2 Max

In b) a common answer was to make an ester. Should say warm with conc. Sulphuric acid in method. Observation should mention 2 layers but not penalised. Better to have state of ester as (l) rather than (aq) but not penalised.

Tertiary alcohols do react with Na and will also make esters.

Question 31 **(6 marks)**

Write observations for the changes occurring when the substances below are mixed. In your answers include the appearance of the reactants and any product(s) that form.

If no change is observed, you should state this.

(a) Solid iodine is added to a solution of magnesium chloride. (2 marks)

Description	Marks
no observable change (no reaction unqualified – not accepted) OR purple / grey solid dissolves in colourless solution to form brown solution (getting this partly correct – 1 mark)	2
Total	**2**

(b) Iron(III) nitrate solution is added to solid copper. (2 marks)

Description	Marks
solution changes from pale brown	1
to pale green / blue (accept green/blue)	1
Total	**2**

Mention of any grey solid forming – lose 1 mark

(b) 2-methylpropene gas is bubbled through a solution of aqueous bromine. (2 marks)

Description	Marks
orange solution	1
fades / turns colourless	1
Total	**2**

Mention of any other substances produced – lose 1 mark

Question 32 **(11 marks)**

(a) 20.0 mL of 0.0401mol L^{-1} hydrochloric acid solution was added to 45.0 mL of 0.0102 mol L^{-1} magnesium hydroxide solution. Calculate the pH of the resulting solution.

(5 marks)

Description	Marks
$n(H^+) = 0.0401 \times 0.020 = 8.02 \times 10^{-4}$ mol $n(OH^-) = 2 \times 0.0102 \times 0.0450 = 9.18 \times 10^{-4}$ mol	1
$n(OH^-)_{excess} = 9.18 \times 10^{-4} - 8.02 \times 10^{-4} = 1.16 \times 10^{-4}$ mol	1
$[OH^-]_{resulting} = 1.16 \times 10^{-4} / 0.065 = 1.78 \times 10^{-3}$ mol L^{-1}	1
$[H^+] = 1.00 \times 10^{-14} / 1.78 \times 10^{-3} = 5.60 \times 10^{-12}$ mol L^{-1}	1
pH = -log(5.60×10^{-12}) **= 11.3**	1
Answer must be 3 significant figures (1 mark penalty)	-1
Total	**5**

If $n(OH^-)$ incorrect and H^+ deemed in excess, one error + one less stage done = 3 marks awarded

(b) The experiment in (a) was repeated, but this time using 20.0 mL of 0.0401 mol L^{-1} ethanoic (acetic) acid solution instead of the hydrochloric acid. Would the pH of the final solution be the same or different from the answer calculated in part (a)? Explain your reasoning (no calculations are required).

(3 marks)

Description	Marks
the same	1
the ethanoic acid will totally ionise / react to completion due to the presence of the strong base, NaOH	1
therefore, the number of moles of hydrogen/ hydronium ions provided to the solution will be the same for both acids	1
Total	**3**

Error carried forward for first mark NOT awarded, but any correctly reasoned chemistry CAN get credit for 2nd or 3rd mark

(c) The experiment in (a) was repeated again, but this time using 20.0 mL of 0.0204 mol L^{-1} sulfuric acid solution instead of the hydrochloric acid. Would the pH of the final solution be the same or different from the answer calculated in part (a)? Explain your reasoning.

(3 marks)

Description	Marks
Different (should be lower)	1
sulfuric acid is a diprotic acid	1
Greater number of moles of H_2SO_4 / comparison on conc or number of moles	1
Total	**3**

Question 33 **(9 marks)**

Carbon disulfide (CS_2) can be manufactured using an endothermic reaction between sulfur trioxide gas and carbon dioxide as shown below:

$$2\ SO_3(g) + CO_2(g) \rightleftharpoons CS_2(g) + 4\ O_2(g)$$

(a) Write an expression for the equilibrium constant of the reaction. (2 marks)

Description	Marks
$K = \frac{[CS_2][O_2]^4}{[SO_2]^2[CO_2]}$	2
Correct species / wrong indices / no "K ="	1
Total	**1**

(b) Predict how each of the following changes to an equilibrium mixture would affect the yield of CS_2. *(Circle the correct outcome – **Increase, Decrease or No effect**)*

(i) lowering the temperature (1 mark)

Increase ***Decrease*** ***No effect***

Description	Marks
decrease	1
Total	**1**

(ii) adding a catalyst (1 mark)

Increase ***Decrease*** ***No effect***

Description	Marks
no change	1
Total	**1**

(iii) increasing the pressure by introducing argon gas into the reaction vessel (at constant volume) (1 mark)

Increase ***Decrease*** ***No effect***

Description	Marks
no change	1
Total	**1**

(c) In the production plant, the carbon disulfide is removed from the reaction vessel on a regular basis. Using collision theory, explain how this technique will increase the yield of the reaction. (4 marks)

Description	Marks
the **concentration** of the carbon disulfide is reduced	1
this reduces the **rate** of the reverse reaction due to less collisions	1
the **rate** of the forward reaction is not affected	1
therefore there is a 'net forward reaction' / the forward reaction is favoured/ products are favoured / the equilibrium shifts to the right	1
Total	**4**

Not enough to state increased yield, given in question

Section Three: Extended answer **40% (80 marks)**

This section contains five (**5)** questions. You must answer **all** questions. Write your answers in the spaces provided.

Where questions require an explanation and/or description, marks are awarded for the relevant chemical content and also for coherence and clarity of expression. Lists or dot points are unlikely to gain full marks.

Final answers to calculations should be expressed to the **appropriate number** of significant figures.

Additional working space pages at the end of this Question/Answer booklet are for planning or continuing an answer. If you use these pages for planning, indicate at the original answer, the page number it is planned/continued on and write the question number being planned/continued on the additional working space page.

Suggested working time: 70 minutes.

Question 34 **(19 marks)**

The opening of Perth Children's Hospital has been delayed due to lead contamination of the drinking water. Lead is a neurotoxin that is particularly harmful to children. One of the possible causes of the contamination was brass fittings. Brass is a metal alloy made of copper and zinc but lead is sometimes added to improve its malleability.

A recent large-scale study on water samples in New South Wales found that low-level lead contamination of water is widespread in Australian homes, with brass tap fittings the most likely source. In a subsequent experiment, the researchers tested water before and after it passed through brass taps and stainless-steel taps. Lead was only found in water that had passed through brass ones.

In 2014, the US government mandated a lead limit of 0.25 percent in plumbing fittings. Taps in Australia are typically made of brass that contains lead at a level of about 2 to 4 percent.

(a) Use evidence from the list of standard reduction potentials on your data sheet to explain why lead from brass is more likely than copper to corrode into drinking water.

(2 marks)

Description	Marks
the (standard) reduction potential for Pb^{2+}/Pb is –0.13 V and for Cu^{2+}/Cu +0.34 V Must use some data for this mark	1
which makes lead metal a stronger reducing agent than copper metal / lead oxidises more readily than copper	1
Total	**2**

(b) Write a balanced equation, including state symbols, for the reaction of sulfuric acid with metallic lead.

(2 marks)

$Pb(s) + 2\ H^+(aq) \rightarrow Pb^{2+}_{(aq)} + H_2(g)$

$Pb^{2+}_{(aq)} + SO_4^{2-}(aq) \rightarrow PbSO_4(s)$

OR: Combined both equations:

$Pb\ (s) + H_2SO_4\ (aq) \rightarrow PbSO_4\ (s) + H_2\ (g)$

Description	Marks
correct equations – need both equations / all substances correct	1
correct state symbols for all substances	1
Total	**2**

1 mark was awarded for an almost correct version of the combined equation.
No marks for any equations involving electrons, or unbalanced charges.

(c) In the experiment described in the passage above, identify the independent and dependent variables.

(2 marks)

Description	Marks
independent variable = material used to make **tap**	1
dependent variable = concentration / amount / presence of lead ions in **water**	1
Total	**2**

An experiment was carried out to calculate the percentage of lead in a sample of brass. A 45.13 g sample of brass was dissolved in excess 6.01 mol L^{-1} hydrochloric acid and any non-metallic insoluble solids were filtered out. Then an excess of 0.502 mol L^{-1} sodium sulfate solution was added to precipitate lead(II) sulfate. After washing and drying, this precipitate had a mass of 2.33 g.

(d) (i) Calculate the percentage, by mass, of lead in the sample.

(5 marks)

Description	Marks
$n(PbSO_4) = m / M = 2.33 / 303.27 = 7.683 \times 10^{-3}$ mol	1
$n(Pb) = 7.683 \times 10^{-3}$ mol	1
$m(Pb) = n \times M = 7.683 \times 10^{-3} \times 207.2 = 1.592$ g	1
%(Pb) = (1.592 / 45.13) x 100 = **3.53%**	1
answer to three significant figures	1
Total	**5**

Molar ratio must be clearly shown somehow

(ii) Calculate the minimum volume of the 0.502 mol L^{-1} sodium sulfate solution required to precipitate all of the lead ions. .

(4 marks)

Description	Marks
$n(SO_4^{2-}) = n(Pb^{2+})$	1
$n(Pb^{2+}) = 7.683 \times 10^{-3}$ mol	1
Vol of Na_2SO_4) = n/c = 7.683×10^{-3} / 0.502 = 0.0153L	1
Vol = 15.3 mL *answer to three significant figures*	1
Total	**4**

Molar ratio must be clearly shown somehow

Lead acts as a poison by displacing biologically-active metal cations, such as calcium and zinc, from their proteins that act as enzymes. Calmodulin, for example is an enzyme that regulates a number of body functions, including muscle contraction, metabolism and memory. Lead displaces one calcium atom from the enzyme molecule, thus reducing the enzyme's efficiency.

(e) Briefly describe how the enzymes catalyse chemical reactions occurring in the body. (2 marks)

Description	Marks
provide an alternative reaction pathway / words to that effect	1
with a lower activation energy *(accept 'lowers the activation energy of the chemical reaction' for 2 marks)*	1
Total	**2**

(f) Explain why an enzyme that has lysine and glutamic acid side chains would be susceptible to denaturing by lead ions.

(2 marks)

Description	Marks
Lysine and glutamic acid can form an ionic bond	1
Lead can form an insoluble compound / bond to carboxylate group and disrupt salt bridge	1
Total	**2**

Question 35 **(15 marks)**

Sickle cell anaemia is an inherited red blood cell disorder. People with this disorder have abnormal haemoglobin in their red blood cells. This disorder occurs when the sixth position in the protein chain normally occupied by the amino acid, glutamic acid is replaced with valine.

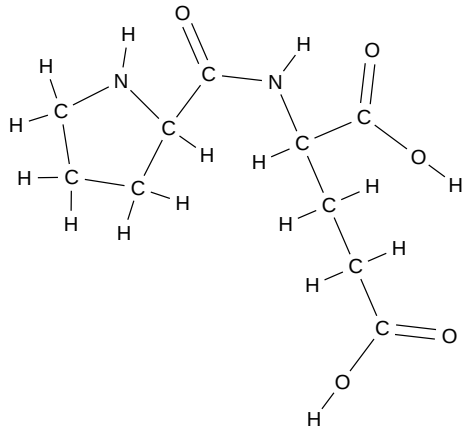
Two sections of each protein chain containing glutamic acid and valine are shown below.

Normal haemoglobin sequence -Val-His-Leu-Thr-Pro-Glu-Glu-

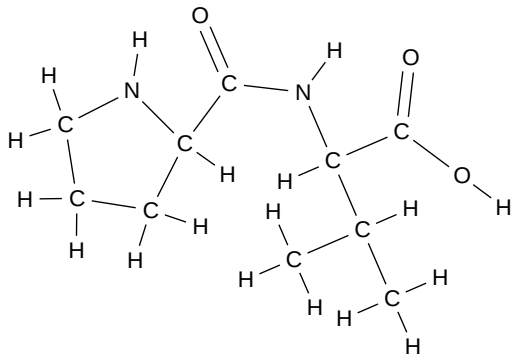
1 2 3 4 5 6 7

Abnormal haemoglobin sequence -Val-His-Leu-Thr-Pro-Val-Glu-

Using a selective enzyme a researcher removed the dipeptide formed by the two amino acids at positions 5 and 6. The structure of the two possible dipeptides are shown below.



Pro-Glu



Pro-Val

In order to determine is the dipeptide was Pro-Glu or Pro-Val a sample was incinerated at 900 ^{o}C and the hot gases were passed through absorbing column where in turn the carbon dioxide and water are removed. The released nitrogen compounds are converted initially to nitrogen dioxide (NO_2) and in the final stage to nitrogen (N_2) at 600 ºC.

A 367 mg sample of the unknown dipeptide was incinerated and 0.754 g of carbon dioxide and 0.278 g of water were collected.

The nitrogen gas that was collected was found to have a volume of 118.4 mL at 600 ºC when the pressure was adjusted to 105 kPa.

(a) Calculate the formula of the combusted sample of the dipeptide.

(9 marks)

Description	Marks
Moles CO_2 = $\frac{0.754}{44.01}$ = 1.7312×10^{-2} Mass C = $1.7312 \times 10^{-2} \times 12.01$ = 0.20576 g % C = $\frac{0.20576}{0.367} \times 100$ = 56.06%	1
Moles H_20 = $\frac{0.278}{18.016}$ = $1.5431X\ 10^{-2}$ Moles H atoms = $2 \times 1.5431X\ 10^{-2}$ = 3.0861×10^{-2}	1
Mass of H = $3.0861 \times 10^{-2} \times 1.008 = 3.1108 \times 10^{-2}$ g % H = $\frac{3.1108 \times 10^{-2}}{0.367} \times 100$ = 8.47%	1
Moles of N_2 = $\frac{PV}{RT} = \frac{105 \times 0.1184}{8.314 \times 873.15} = 1.712 \times 10^{-3}$ Moles of N atoms = $2 \times 1.712 \times 10^{-3} = 3.245 \times 10^{-3}$	1
Mass of N = $3.245 \times 10^{-3} \times 14.01 = 4.7896 \times 10^{-2}$ g % N = $\frac{4.7896 \times 10^{-2}}{0.367} \times 100$ = 13.07 %	1
% O = 100 – (56.06 + 8.47 + 13.07) = 22.4%	1
C H O N In 100g sample (g) 56.06 8.47 22.4 13.07 Moles $\frac{56.06}{12.01}$ $\frac{8.47}{1.008}$ $\frac{22.4}{16}$ $\frac{13.07}{14.01}$ 4.667 8.403 1.40 0.933 ÷ smallest 5.00 9.00 1.5 1 Simplest whole number ratio 10 18 3 2	1 1
Dipeptide formula $C_{10}H_{18}O_3N_2$	1
Total	**9**

(b) Write the molecular formulas for the two dipeptides

(2 marks)

(i) Pro-Glu

Description	Mark
$C_{10}H_{16}0_5N_2$	1
Total	**1**

(ii) Pro-Val

Description	Mark
$C_{10}H_{18}0_3N_2$	1
Total	**1**

(c) Is the sample that was analysed from a person who has sickle cell anemia?
Explain your answer using the information from parts (a) and (b).

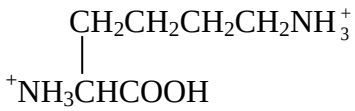
(2 marks)

Description	Mark
Yes the formula for the dipeptide Pro-Val matches the formula from the combustion data	2
A "Yes" response is not given a mark if it is not explained	
Total	**2**

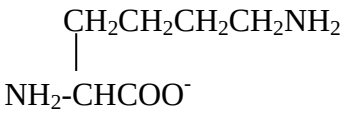
(d) The structural formula, of the alpha amino acid valine, depends upon the pH of the solution it is in. Draw the structure of lysine in:

(2 marks)

(i) Acidic solution



(ii) Basic solution



Question 36 **(14 marks)**

Ethanol production from ethene and steam is one of the most common industrial processes used for food, alcoholic beverages and in both fuel and industry.
The reaction for the production of ethanol from ethene is shown below.

$$CH_2CH_2(g) + H_2O(g) \rightleftharpoons CH_3CH_2OH(g) \qquad \Delta H = -45 \text{ kJ mol}^{-1}$$

This reaction is reversible and the formation of ethanol is exothermic. At normal conditions, the equilibrium is positioned to the left and the amount of ethanol formed is quite small, therefore, to significantly increase the yield of ethanol, the reaction is carried out at 300 ^{o}C and about 60-70 atmospheric pressure using phosphoric acid as a catalyst.

(a) Explain how by carrying out the reaction at 300 ^{o}C and about 60-70 atmospheres of pressure (approximately 6-7 MPa) using phosphoric acid as a catalyst increases the yield of ethanol

(2 marks)

Description	Marks
The catalyst reduces the amount of energy required to obtain an economic rate of reaction	1
Increasing the pressure shifts the position of equilibrium to the right	1
Total	**2**

(b) Use sustainability principles to explain why it may be beneficial to source ethanol through a fermentation process rather than the reaction shown above.

(2 marks)

Description	Marks
fermentation uses biomass to produce ethanol	1
biomass is renewable whereas ethene is sourced from non-renewable crude oil	1
Total	**2**

(c) It was found that 170.8 kg of ethanol was produced from 201.2 kg of ethene gas. Calculate the percentage yield of this reaction.

(4 marks)

Description	Marks
$n(CH_2CH_2) = 201\ 200 / 28.052 = 7\ 172.4$ mol	1
$n(CH_3CH_2OH)_{expected} = n(CH_2CH_2) = 7\ 172.4$ mol	1
$m(CH_3CH_2OH)_{expected} = 7172.4 \times 46.068 = 330\ 418$ g	1
% yield = (170800 / 330418) x 100 = 51.69 % (must be 4 sig fig)	1
Total	**4**

The ethanol from this reaction can be used to make ethyl ethanoate.

(d) Write an equation for this reaction, and state the conditions required.

(2 marks)

Description	Marks
$CH_3CH_2OH + CH_3COOH \rightarrow CH_3COOCH_2CH_3 + H_2O$	1
(sulfuric) acid catalyst	1
Total	**2**

(e) A manufacturing facility has adjusted the parameters to establish a reaction yield (efficiency) for the production of ethyl ethanoate as 67.0%. Calculate the mass of ethanol required per tonne (1.00×10^6 g) of ethyl ethanoate produced.

(4 marks)

Description	Marks
$n(CH_3COOCH_2CH_3) = 1.00 \times 10^6 / 88.104 = 11350$ mol	1
$n(CH_3CH_2OH)_{requiired} = (1/1) \times (100/67.0) \times 11350$ mol $= 16940$ mol	1
$n(CH_3CH_2OH)_{requiired} = 16940 \times 46.068 = 780\ 392$ g $= 780$ kg	1
three significant figures used	1
Total	**4**

Question 37 **(20 marks)**

A team of students competing in a competition to test their titration skills were tasked with using a standard solution of 0.1023 mol L^{-1} hydrochloric acid to standardise a solution of sodium hydroxide. They then had to use this sodium hydroxide solution to determine the concentration of a solution of a weak monoprotic acid, benzoic acid (C_6H_5COOH).

They were provided with two indicators, whose names and pH ranges are given below.

Indicator	Acid colour	pH range of colour change	Base colour
Phenolphthalein	colourless	8.2 – 10.0	pink
Methyl Red	red	4.8 – 6.0	yellow

The students placed the sodium hydroxide solution in the burette for both titrations and used methyl red indicator for the standardisation of the sodium hydroxide and phenolphthalein for the standardisation of the benzoic acid.

They found that an average of 23.55 mL of sodium hydroxide solution was required to neutralise 20.00 mL aliquots of the 0.1023 mol L^{-1} hydrochloric acid.

(a) Calculate the concentration of the sodium hydroxide solution.

(3 marks)

Description	Marks
n(HCl) = c × V = 0.1023 × 0.0200 = 0.002046 mol	1
n(NaOH) = 0.002046 mol	1
c(NaOH) = 0.002046 / 0.02355 **= 0.08688 mol L^{-1}** **(to 4 sig figs)**	1
Total	**3**

Significant figure important for these questions

They then titrated the sodium hydroxide against 25.00 mL aliquots of the benzoic acid and obtained the following results, using phenolphthalein as the indicator.

Volume of sodium hydroxide	Titrations			
	1	2	3	4
Final Reading (mL)	17.70	35.15	19.45	36.85
Initial Reading (mL)	0.00	17.70	2.00	19.45
Titre volume (mL)	**17.70**	**17.45**	**17.45**	**17.40**

(b) Complete the table and calculate the concentration of the benzoic acid solution.

Note: if you were unable to calculate the concentration of the sodium hydroxide solution in part (a), use a concentration of 0.1032 mol L^{-1} for the rest of this question.

(i) in moles per litre. (4 marks)

Description	Marks
$V(NaOH)_{average}$ = (17.45 + 17.45 + 17.40)/3 = 17.43 mL = 0.01743 L	1
n(NaOH) = 0.0869 x 0.01743 = 0.001515 mol	1
$n(C_6H_5COOH))$ = (1/1) x n(NaOH) = 0.001515 mol	1
$c(C_6H_5COOH)$ = 0.001515 / 0.02500 = **0.06057 mol L^{-1}**	1
Answer must be to 4 sig figs	-1
Total	**4**

Significant figure important for these questions

(ii) as a percentage by mass (the mass of 25.0 mL sample of benzoic acid is 26.25 g)

(3 marks)

Description	Marks
Moles of C_6H_5COOH = 0.0606 x 0.025 = 1.5143 x 10^{-3} mol	1
Mass of C_6H_5COOH = 1.5143 x 10^{-3} x 122.12 = 0.18493 g	1
%($C_6H_5COOH)_{by\ mass}$ = (0.18493 /26.25) x 100 **= 0.704%**	1
Answer must be to 3 sig figs	-1
Total	**3**

Significant figure important for these questions

The team was then asked to calculate the concentration of another solution of benzoic acid that has been prepared by a laboratory technician.

They carried out the same method and found that only 4.15 mL of the standardised sodium hydroxide was required to neutralise a 20 mL aliquot of the new benzoic acid. Because of the low volumes for the titre, the effect of any random error in these results is increased.

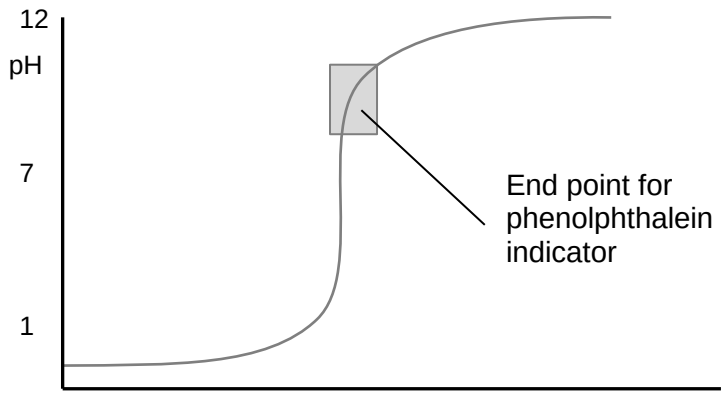
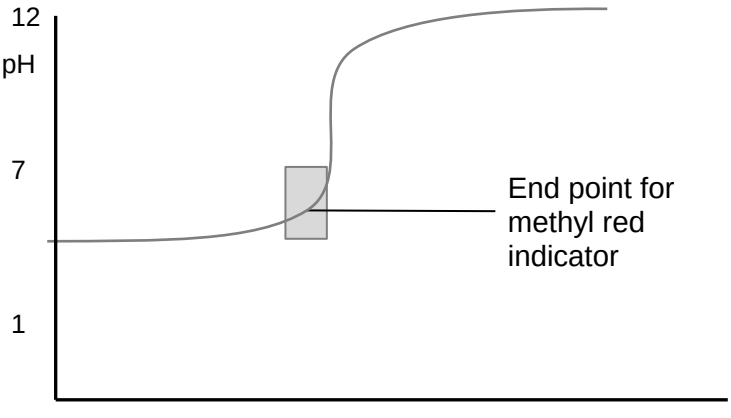
(c) Describe, including quantities of chemicals, how the method of the experiment can be revised to ensure that the volumes of the titres of sodium hydroxide from the burette are approximately 20.00 mL, thus giving more accurate results.

(4 marks)

Description	Marks
The concentration of the benzoic acid is too high	1
aiming for 20.00 mL titres so need to dilute the NaOH solution by a factor of 20.0/4.15 ≈ 4.8 ≈ 5	1
pipette 20.00 mL of the standardised NaOH into 100 mL volumetric flask and make up the volume to 100 mL using distilled water.	1
use this diluted NaOH solution to titrate against the second sample of benzoic acid	1
Total	**4**

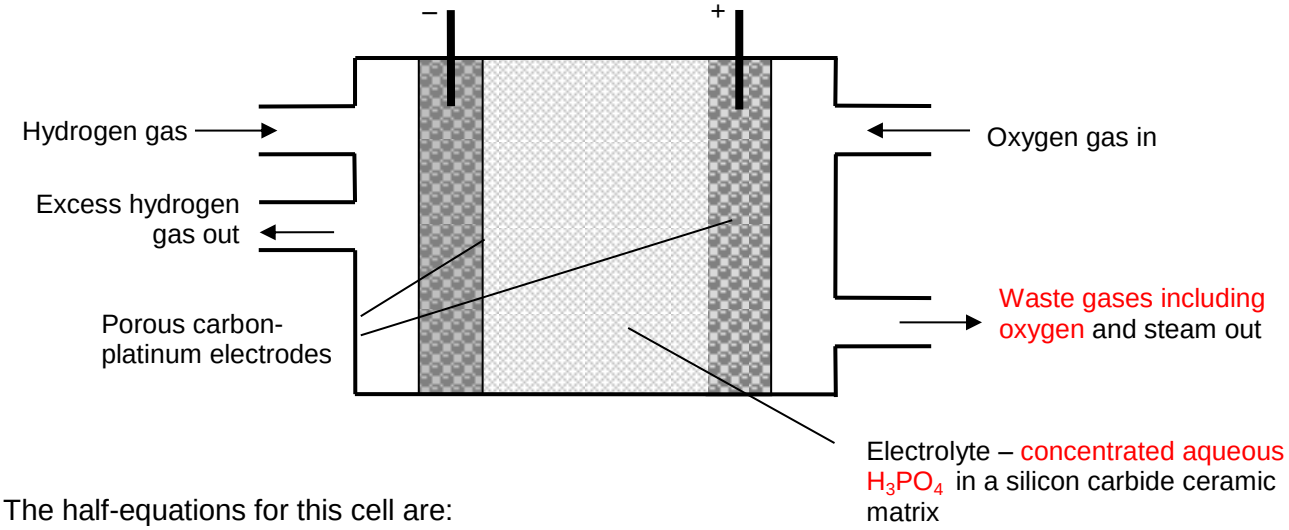
(d) Another team, mistakenly used phenolphthalein indicator for the standardisation of the sodium hydroxide and methyl red for the standardisation of the benzoic acid. Explain in detail how this mistake would affect the precision and accuracy of their results. You can use sketches of graphs in your response.

(6 marks)

Description	Marks
The first titration of the sodium hydroxide and hydrochloric acid is between a strong acid and a strong base.	1
So the phenolphthalein will still change colour close to the equivalence point. (can be shown on titration curve)  	1
Therefore this will lead to small amount of (systematic) error in the concentration of the concentration of the sodium hydroxide solution. (higher volume recorded so calculated concentration will be lower than actual value)	1
The second titration of the sodium hydroxide and ethanoic acid is between a weak acid and a strong base so the equivalence point will be basic.	1
So the end point will be significantly different from the equivalence point. (can be shown on titration curve)  	1
The volume recorded for the NaOH will be significantly less than the correct reading and therefore the calculated concentration of the sodium hydroxide will be much higher than the actual value.	**1**
Total	**6**

Question 38 **(12 marks)**

The following diagram represents a phosphoric acid fuel cell. These cells operate at temperatures between 150–200°C and are used as backup power and energy supply for places like banks and hospitals.



The half-equations for this cell are:

Anode: $H_2(g) \rightarrow 2\ H^+(aq) + 2\ e^-$

Cathode: $O_2(g) + 4\ H^+(aq) + 4\ e^- \rightarrow 2\ H_2O(\ell \text{ and } g)$

(a) Examine the diagram and

(i) give two specific reasons why the phosphoric acid fuel cell does not produce the predicted 1.23 volts. Using data from the table of Standard Reduction Potentials the E_{cell} was predicted to be 1.23 V. However, the voltage measured from this fuel cell was 0.7 (2 marks)

Description	Marks
Two of the following Temperature not 25 ^{0} C Gases not at 100 kPa Not standard reduction equation at cathode	
Total	**2**

(ii) explain why the porous nature of the electrode aids the process occurring at the anode. (2 marks)

Description	Marks
Allows oxygen gas to move to electrolyte	1
to allow the hydrogen ions to react with the oxygen gas	1
Total	**2**

(iii) suggest specifically why a high temperature is used in this cell. (1 mark)

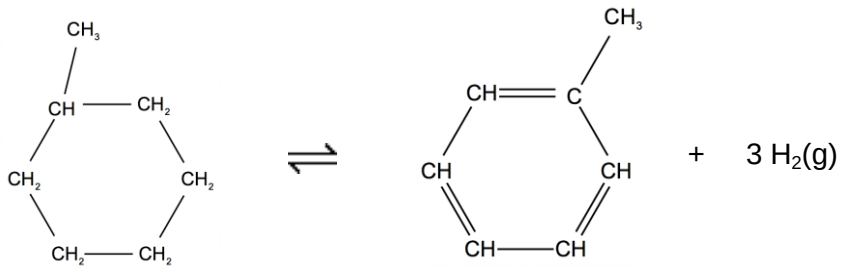
Description	Marks
Operates at temperature above boiling point of water which allow it to be removed without dilution electrolyte	1
Total	**1**

(b) Write the overall redox reaction from the fuel cell and describe one advantage and one disadvantage of the use of the fuel cell directly related to this equation.

(3 marks)

Description	Marks
$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(g)$	1
Advantage: the only product of the cell is water (steam which can be used else were)	1
Disadvantage: hydrogen supplied from fossil fuel methane	1
Total	**3**

(c) The hydrogen used in fuel cells can be synthesised using a range of reactions. One example is the endothermic dehydrogenation of methyl cyclohexane into methylbenzene (toluene) shown below. To maximise the yield the reaction occurs at a high pressure and temperature.



+ $3\ H_2(g)$

Assuming an 80.0% yield for this reaction, calculate the volume of hydrogen gas at 500°C and 650 kPa produced for every 1000 g of methyl cyclohexane.

(4 marks)

Description	Marks
Moles $C_7H_{14} = \frac{1000}{98.182} = 10.185$ moles	1
Moles H_2 = 3 moles of methylcyclohexane = 3 x 10.185 = 30.555 moles	1
At 80% efficiency moles H_2 = 0.80 x 30.555 = 24.44 moles	1
Volume of hydrogen $V = \frac{nRT}{P} \quad \frac{24.44 \times 8.314 \times 773.15}{650} = 241.74 = 242$ L	1
Must be 3 sig figs	**-1**
Total	**4**

Significant figure important for these questions

---------- End of paper ----------